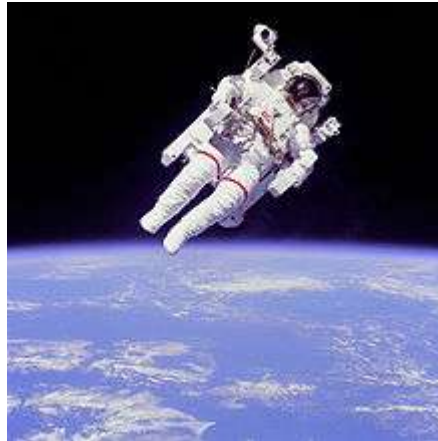


Technology

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By the mid 20th century, humans had achieved a mastery of technology sufficient to leave the atmosphere of the Earth for the first time and [explore space](#).

Technology is the usage and knowledge of [tools](#), techniques, [crafts](#), [systems](#) or methods of organization. The word *technology* comes from the [Greek](#) *technología* (*τεχνολογία*) — *téchnē* (*τέχνη*), an 'art', 'skill' or 'craft' and *-logía* (*-λογία*), the study of something, or the branch of knowledge of a discipline.^[1] The term can either be applied generally or to specific areas: examples include *construction technology*, *medical technology*, or *state-of-the-art technology* or *high technology*. Technologies can also be exemplified in a material product, for example an object can be termed state of the art.

Technologies significantly affect human as well as other animal species' ability to control and adapt to their natural environments. The human species' use of technology began with the conversion of natural resources into simple tools. The [prehistorical](#) discovery of the ability to control [fire](#) increased the available sources of food and the invention of the [wheel](#) helped humans in travelling in and controlling their environment. Recent technological developments, including the [printing press](#), the [telephone](#), and the [Internet](#), have lessened physical barriers to [communication](#) and allowed humans to interact freely on a global scale. However, not all technology has been used for peaceful purposes; the development of [weapons](#) of ever-increasing destructive power has progressed throughout history, from [clubs](#) to [nuclear weapons](#).

Technology has affected [society](#) and its surroundings in a number of ways. In many societies, technology has helped develop more advanced [economies](#) (including today's [global economy](#)) and has allowed the rise of a [leisure class](#). Many technological processes produce unwanted by-products, known as [pollution](#), and deplete natural resources, to the detriment of the [Earth](#) and its [environment](#). Various implementations of technology influence the [values](#) of a society and new technology often raises new ethical questions. Examples include the rise of the notion of [efficiency](#) in terms of human productivity, a term originally applied only to machines, and the challenge of traditional norms.

Philosophical debates have arisen over the present and future use of technology in society, with disagreements over whether technology improves the [human condition](#) or worsens it. [Neo-Luddism](#), [anarcho-primitivism](#), and similar movements criticise the pervasiveness of technology in the modern world, opining that it harms the environment and alienates people; proponents of ideologies such as [transhumanism](#) and [techno-progressivism](#) view continued technological progress as beneficial to society and the human condition. Indeed, until recently, it was believed that the development of technology was restricted only to human beings, but recent scientific studies indicate that other [primates](#) and certain [dolphin](#) communities have developed simple tools and learned to pass their knowledge to other generations.

Definition and usage



The invention of the [printing press](#) made it possible for scientists and [politicians](#) to communicate their ideas with ease, leading to the [Age of Enlightenment](#); an example of technology as a cultural force.

The use of the term *technology* has changed significantly over the last 200 years. Before the 20th century, the term was uncommon in English, and usually referred to the description or study of the useful arts.^[2] The term was often connected to technical education, as in the Massachusetts Institute of Technology (chartered in 1861).^[3] "Technology" rose to prominence in the 20th century in connection with the [second industrial revolution](#). The meanings of technology changed in the early 20th century when American social scientists, beginning with [Thorstein Veblen](#), translated ideas from the German concept of [Technik](#) into "technology." In German and other European languages, a distinction exists between *Technik* and *Technologie* that is absent in English, as both terms are usually translated as "technology." By the 1930s, "technology" referred not to the study of the industrial arts, but to the industrial arts themselves.^[4] In 1937, the American sociologist Read Bain wrote that "technology includes all tools, machines, utensils, weapons, instruments, housing, clothing, communicating and transporting devices and the skills by which we produce and use them."^[5] Bain's definition remains common among scholars today, especially social scientists. But equally prominent is the definition of technology as applied science, especially among scientists and engineers, although most social scientists who study technology reject this definition.^[6] More recently, scholars have borrowed from European philosophers of

"technique" to extend the meaning of technology to various forms of instrumental reason, as in Foucault's work on [technologies of the self](#) ("techniques de soi").

Dictionaries and scholars have offered a variety of definitions. The [Merriam-Webster](#) dictionary offers a definition of the term: "the practical application of knowledge especially in a particular area" and "a capability given by the practical application of knowledge".^[1] [Ursula Franklin](#), in her 1989 "Real World of Technology" lecture, gave another definition of the concept; it is "practice, the way we do things around here".^[7] The term is often used to imply a specific field of technology, or to refer to [high technology](#) or just [consumer electronics](#), rather than technology as a whole.^[8] [Bernard Stiegler](#), in *Technics and Time, 1*, defines technology in two ways: as "the pursuit of life by means other than life", and as "organized inorganic matter."^[9]

Technology can be most broadly defined as the entities, both material and immaterial, created by the application of mental and physical effort in order to achieve some value. In this usage, technology refers to tools and machines that may be used to solve real-world problems. It is a far-reaching term that may include simple tools, such as a [crowbar](#) or wooden [spoon](#), or more complex machines, such as a [space station](#) or [particle accelerator](#). Tools and machines need not be material; virtual technology, such as [computer software](#) and [business methods](#), fall under this definition of technology.^[10]

The word "technology" can also be used to refer to a collection of techniques. In this context, it is the current state of humanity's knowledge of how to combine resources to produce desired products, to solve problems, fulfill needs, or satisfy wants; it includes technical methods, skills, processes, techniques, tools and raw materials. When combined with another term, such as "medical technology" or "space technology", it refers to the state of the respective field's knowledge and tools. "[State-of-the-art](#) technology" refers to the [high technology](#) available to humanity in any field.

Technology can be viewed as an activity that forms or changes culture.^[11] Additionally, technology is the application of math, science, and the arts for the benefit of life as it is known. A modern example is the rise of [communication](#) technology, which has lessened barriers to human interaction and, as a result, has helped spawn new subcultures; the rise of [cyberculture](#) has, at its basis, the development of the [Internet](#) and the [computer](#).^[12] Not all technology enhances culture in a creative way; technology can also help facilitate political oppression and war via tools such as guns. As a cultural activity, technology predates both [science](#) and [engineering](#), each of which formalize some aspects of technological endeavor.

Science, engineering and technology

The distinction between science, engineering and technology is not always clear. [Science](#) is the [reasoned](#) investigation or study of phenomena, aimed at discovering enduring principles among elements of the [phenomenal](#) world by employing [formal](#) techniques such as the [scientific method](#).^[13] Technologies are not usually exclusively products of science, because they have to satisfy requirements such as [utility](#), [usability](#) and [safety](#).

Engineering is the [goal-oriented](#) process of designing and making tools and systems to exploit natural phenomena for practical human means, often (but not always) using results and techniques from science. The development of technology may draw upon many fields of

knowledge, including scientific, engineering, [mathematical](#), [linguistic](#), and [historical](#) knowledge, to achieve some practical result.

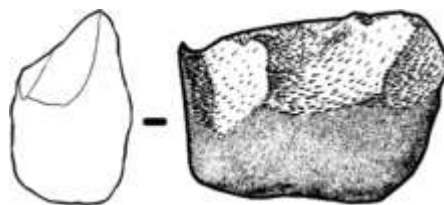
Technology is often a consequence of science and engineering — although technology as a human activity precedes the two fields. For example, science might study the flow of [electrons](#) in [electrical conductors](#), by using already-existing tools and knowledge. This new-found knowledge may then be used by engineers to create new tools and machines, such as [semiconductors](#), [computers](#), and other forms of advanced technology. In this sense, scientists and engineers may both be considered technologists; the three fields are often considered as one for the purposes of research and reference.^[14]

The exact relations between science and technology in particular have been debated by scientists, historians, and policymakers in the late 20th century, in part because the debate can inform the funding of basic and applied science. In the immediate wake of [World War II](#), for example, in the United States it was widely considered that technology was simply "applied science" and that to fund basic science was to reap technological results in due time. An articulation of this philosophy could be found explicitly in [Vannevar Bush](#)'s treatise on postwar science policy, *Science—The Endless Frontier*: "New products, new industries, and more jobs require continuous additions to knowledge of the laws of nature... This essential new knowledge can be obtained only through basic scientific research." In the late-1960s, however, this view came under direct attack, leading towards initiatives to fund science for specific tasks (initiatives resisted by the scientific community). The issue remains contentious—though most analysts resist the model that technology simply is a result of scientific research.^{[15][16]}

History

Main articles: [History of technology](#) and [Timeline of historic inventions](#)

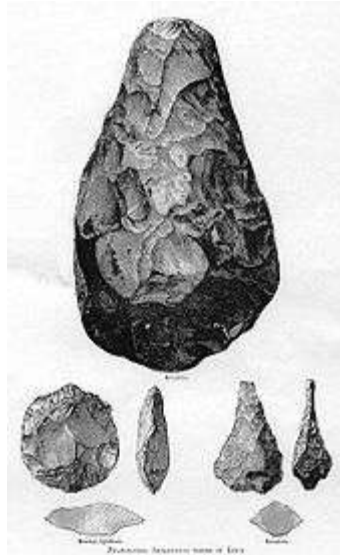
Paleolithic (2.5 million – 10,000 BC)



A primitive [chopper](#)

The use of tools by [early humans](#) was partly a process of discovery, partly of evolution. Early humans evolved from a [species](#) of [foraging hominids](#) which were already [bipedal](#),^[17] with a brain mass approximately one third that of modern humans.^[18] Tool use remained relatively unchanged for most of early human history, but approximately 50,000 years ago, a [complex set of behaviors](#) and tool use emerged, believed by many archaeologists to be connected to the emergence of fully modern [language](#).^[19]

Stone tools



Hand axes from the [Acheulian](#) period



A [Clovis point](#), made via [pressure flaking](#)

Human ancestors have been using stone and other tools since long before the emergence of [Homo sapiens](#) approximately 200,000 years ago.^[20] The earliest methods of [stone tool](#) making, known as the [Oldowan](#) "industry", date back to at least 2.3 million years ago,^[21] with the earliest direct evidence of tool usage found in [Ethiopia](#) within the [Great Rift Valley](#), dating back to 2.5 million years ago.^[22] This era of stone tool use is called the [Paleolithic](#), or "Old stone age", and spans all of human history up to the development of [agriculture](#) approximately 12,000 years ago.

To make a stone tool, a "[core](#)" of hard stone with specific flaking properties (such as [flint](#)) was struck with a [hammerstone](#). This flaking produced a sharp edge on the core stone as well as on the flakes, either of which could be used as tools, primarily in the form of [choppers](#) or [scrapers](#).^[23] These tools greatly aided the early humans in their [hunter-gatherer](#) lifestyle to perform a variety of tasks including butchering carcasses (and breaking bones to get at the [marrow](#)); chopping wood; cracking open nuts; skinning an animal for its [hide](#); and even forming other tools out of softer materials such as bone and wood.^[24]

The earliest stone tools were crude, being little more than a fractured rock. In the [Acheulian](#) era, beginning approximately 1.65 million years ago, methods of working these stone into specific shapes, such as [hand axes](#) emerged. The [Middle Paleolithic](#), approximately 300,000 years ago, saw the introduction of the [prepared-core technique](#), where multiple blades could be rapidly formed from a single core stone.^[23] The [Upper Paleolithic](#), beginning approximately 40,000 years ago, saw the introduction of [pressure flaking](#), where a wood, bone, or antler [punch](#) could be used to shape a stone very finely.^[25]

Fire

The discovery and utilization of fire, a simple [energy](#) source with many profound uses, was a turning point in the technological evolution of humankind.^[26] The exact date of its discovery is not known; evidence of burnt animal bones at the [Cradle of Humankind](#) suggests that the domestication of fire occurred before 1,000,000 BC;^[27] scholarly consensus indicates that [Homo erectus](#) had controlled fire by between 500,000 BC and 400,000 BC.^{[28][29]} Fire, fueled with [wood](#) and [charcoal](#), allowed early humans to cook their food to increase its digestibility, improving its nutrient value and broadening the number of foods that could be eaten.^[30]

Clothing and shelter

Other technological advances made during the Paleolithic era were [clothing](#) and shelter; the adoption of both technologies cannot be dated exactly, but they were a key to humanity's progress. As the Paleolithic era progressed, dwellings became more sophisticated and more elaborate; as early as 380,000 BC, humans were constructing temporary wood huts.^{[31][32]} Clothing, adapted from the fur and hides of hunted animals, helped humanity expand into colder regions; humans began to [migrate](#) out of Africa by 200,000 BC and into other continents, such as [Eurasia](#).^[33]

Neolithic through Classical Antiquity (10,000BC – 300AD)



An array of Neolithic artifacts, including bracelets, axe heads, chisels, and polishing tools.

Man's technological ascent began in earnest in what is known as the [Neolithic](#) period ("New stone age"). The invention of polished [stone axes](#) was a major advance because it allowed forest clearance on a large scale to create farms. The discovery of [agriculture](#) allowed for the feeding of larger populations, and the transition to a [sedentist](#) lifestyle increased the number of children that could be simultaneously raised, as young children no longer needed to be carried, as was the case with the nomadic lifestyle. Additionally, children could contribute labor to the raising of crops more readily than they could to the hunter-gatherer lifestyle.^{[34][35]}

With this increase in population and availability of labor came an increase in labor specialization.^[36] What triggered the progression from early Neolithic villages to the first cities, such as [Uruk](#), and the first civilizations, such as [Sumer](#), is not specifically known; however, the emergence of increasingly [hierarchical](#) social structures, the specialization of labor, trade and war amongst adjacent cultures, and the need for collective action to overcome environmental challenges, such as the building of [dikes](#) and [reservoirs](#), are all thought to have played a role.^[37]

Metal tools

Continuing improvements led to the [furnace](#) and [bellows](#) and provided the ability to [smelt](#) and [forge](#) native metals (naturally occurring in relatively pure form).^[38] [Gold](#), [copper](#), [silver](#), and [lead](#), were such early metals. The advantages of copper tools over stone, bone, and wooden tools were quickly apparent to early humans, and native copper was probably used from near the beginning of [Neolithic](#) times (about 8000 BC).^[39] Native copper does not naturally occur in large amounts, but copper ores are quite common and some of them produce metal easily when burned in wood or charcoal fires. Eventually, the working of metals led to the discovery of [alloys](#) such as [bronze](#) and [brass](#) (about 4000 BC). The first uses of iron alloys such as [steel](#) dates to around 1400 BC.

Energy and Transport



 The [wheel](#) was invented circa 4000 BC.

Meanwhile, humans were learning to harness other forms of energy. The earliest known use of wind power is the sailboat.^[40] The earliest record of a ship under sail is shown on an Egyptian pot dating back to 3200 BC.^[41] From prehistoric times, Egyptians probably used "the power of the Nile" annual floods to irrigate their lands, gradually learning to regulate much of it through purposely built irrigation channels and 'catch' basins. Similarly, the early peoples of Mesopotamia, the Sumerians, learned to use the Tigris and Euphrates rivers for much the same purposes. But more extensive use of wind and water (and even human) power required another invention.

According to archaeologists, the [wheel](#) was invented around 4000 B.C. The wheel was probably independently invented in Mesopotamia (in present-day [Iraq](#)) as well. Estimates on when this may have occurred range from 5500 to 3000 B.C., with most experts putting it closer to 4000 B.C. The oldest artifacts with drawings that depict wheeled carts date from about 3000 B.C.; however, the wheel may have been in use for millennia before these drawings were made. There is also evidence from the same period of time that wheels were

used for the production of [pottery](#). (Note that the original potter's wheel was probably not a wheel, but rather an irregularly shaped slab of flat wood with a small hollowed or pierced area near the center and mounted on a peg driven into the earth. It would have been rotated by repeated tugs by the potter or his assistant.) More recently, the oldest-known wooden wheel in the world was found in the Ljubljana marshes of Slovenia.^[42]

The invention of the wheel revolutionized activities as disparate as transportation, war, and the production of pottery (for which it may have been first used). It didn't take long to discover that wheeled wagons could be used to carry heavy loads and fast (rotary) potters' wheels enabled early mass production of pottery. But it was the use of the wheel as a transformer of energy (through water wheels, windmills, and even treadmills) that revolutionized the application of nonhuman power sources.

Medieval and Modern history (300 AD —)

Main articles: [Medieval technology](#), [Renaissance technology](#), and [Industrial Revolution](#)

Innovations continued through the [Middle Ages](#) with new innovations such as [silk](#), the [horse collar](#) and [horseshoes](#) in the first few hundred years after the fall of the [Roman Empire](#). [Medieval technology](#) saw the use of [simple machines](#) (such as the [lever](#), the [screw](#), and the [pulley](#)) being combined to form more complicated tools, such as the [wheelbarrow](#), [windmills](#) and [clocks](#). The [Renaissance](#) brought forth many of these innovations, including the [printing press](#) (which facilitated the greater communication of knowledge), and technology became increasingly associated with [science](#), beginning a cycle of mutual advancement. The advancements in technology in this era allowed a more steady supply of food, followed by the wider availability of consumer goods.

Starting in the United Kingdom in the 18th century, the [Industrial Revolution](#) was a period of great technological discovery, particularly in the areas of [agriculture](#), [manufacturing](#) [mining](#), [metallurgy](#) and [transport](#), driven by the discovery of [steam power](#). Technology later took another step with the harnessing of [electricity](#) to create such innovations as the [electric motor](#), [light bulb](#) and countless others. Scientific advancement and the discovery of new concepts later allowed for [powered flight](#), and advancements in [medicine](#), [chemistry](#), [physics](#) and [engineering](#). The rise in technology has led to the construction of [skyscrapers](#) and large cities whose inhabitants rely on [automobiles](#) or other powered transit for transportation. Communication was also improved with the invention of the [telegraph](#), [telephone](#), [radio](#) and [television](#).

The second half of the 20th century brought a host of new innovations. In [physics](#), the discovery of [nuclear fission](#) has led to both [nuclear weapons](#) and [nuclear energy](#). [Computers](#) were also invented later [miniaturized](#) with [transistors](#) and [integrated circuits](#), with the creation of the [Internet](#) resulting after. Humans have also been able to [explore space](#) with [satellites](#) (later used for [telecommunication](#)) and in manned missions going all the way to the moon. In medicine, this era brought innovations such as [open-heart surgery](#) and later [stem cell therapy](#) along with new [medications](#) and treatments. Complex [manufacturing](#) and [construction](#) techniques and organizations are needed to construct and maintain these new technologies, and entire [industries](#) have arisen to support and develop succeeding generations of increasingly more complex tools. Modern technology increasingly relies on training and education — their designers, builders, maintainers, and often users often require sophisticated general and specific training. Moreover, these technologies have become so complex that

entire fields have been created to support them, including [engineering](#), [medicine](#), and [computer science](#), and other fields have been made more complex, such as [construction](#), [transportation](#) and [architecture](#).

Technology and philosophy

Technicism

Generally, [technicism](#) is an over reliance or overconfidence in technology as a benefactor of society. Taken to extreme, technicism is the belief that humanity will ultimately be able to control the entirety of existence using technology. In other words, human beings will someday be able to master all problems and possibly even control the future using technology. Some, such as [Stephen V. Monsma](#),^[43] connect these ideas to the abdication of religion as a higher moral authority.

Optimism

See also: [Extropianism](#)

Optimistic assumptions are made by proponents of ideologies such as [transhumanism](#) and [singularitarianism](#), which view [technological development](#) as generally having beneficial effects for the society and the human condition. In these ideologies, technological development is morally good. Some critics see these ideologies as examples of [scientism](#) and [techno-utopianism](#) and fear the notion of [human enhancement](#) and [technological singularity](#) which they support. Some have described [Karl Marx](#) as a techno-optimist.^[44]

Pessimism

See also: [Luddite](#), [Neo-luddism](#), [Anarcho-primitivism](#), and [Bioconservatism](#)

On the somewhat pessimistic side are certain philosophers like [Herbert Marcuse](#) and [John Zerzan](#), who believe that technological societies are inherently flawed *a priori*. They suggest that the result of such a society is to become evermore technological at the cost of freedom and psychological health.

Many, such as the [Luddites](#) and prominent philosopher [Martin Heidegger](#), hold serious reservations, although not *a priori* flawed reservations, about technology. Heidegger presents such a view in "[The Question Concerning Technology](#)": "Thus we shall never experience our relationship to the essence of technology so long as we merely conceive and push forward the technological, put up with it, or evade it. Everywhere we remain unfree and chained to technology, whether we passionately affirm or deny it."^[45]

Some of the most poignant criticisms of technology are found in what are now considered to be dystopian literary classics, for example [Aldous Huxley's *Brave New World*](#) and other writings, [Anthony Burgess's *A Clockwork Orange*](#), and [George Orwell's *Nineteen Eighty-Four*](#). And, in [Faust](#) by [Goethe](#), Faust's selling his soul to the devil in return for power over

the physical world, is also often interpreted as a metaphor for the adoption of industrial technology.

An overtly anti-technological treatise is [*Industrial Society and Its Future*](#), written by [Theodore Kaczynski](#) (aka The [Unabomber](#)) and printed in several major newspapers (and later books) as part of an effort to end his bombing campaign of the techno-industrial infrastructure.

Appropriate technology

See also: [Technocriticism](#) and [Technorealism](#)

The notion of [appropriate technology](#), however, was developed in the 20th century (e.g., see the work of [Jacques Ellul](#)) to describe situations where it was not desirable to use very new technologies or those that required access to some centralized [infrastructure](#) or parts or skills imported from elsewhere. The [eco-village](#) movement emerged in part due to this concern.

Other animal species



This adult [gorilla](#) uses a branch as a [walking stick](#) to gauge the water's depth; an example of technology usage by primates.

The use of basic technology is also a feature of other animal species apart from humans. These include primates such as [chimpanzees](#), some [dolphin](#) communities,^{[46][47]} and [crows](#).^{[48][49]} Considering a more generic perspective of technology as ethology of active environmental conditioning and control, we can also refer to animal examples such as beavers and their dams, or bees and their honeycombs.

The ability to make and use tools was once considered a defining characteristic of the genus [Homo](#).^[50] However, the discovery of tool construction among chimpanzees and related primates has discarded the notion of the use of technology as unique to humans. For example, researchers have observed wild chimpanzees utilising tools for foraging: some of the tools used include leaf sponges, termite fishing probes, [pestles](#) and [levers](#).^[51] West African [chimpanzees](#) also use stone hammers and anvils for cracking nuts,^[52] as do [capuchin monkeys](#) of [Boa Vista](#), Brazil.^[53]

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